THE THEORY OF RELATIVITY HAS BECOME WIDELY KNOWN, BUT IT WOULD BE RASH TO SAY THAT IT HAS BEEN WIDELY UNDERSTOOD

— John Stachel.

ARGUMENTS AGAINST TACHYONS (T)

IP = Invariance Principle
PIP = philosophically-grounded version of IP.
FSP = First Signal Principle

① Einstein's Argument

$$IP \rightarrow FSP$$
$$T \rightarrow \sim FSP \rightarrow \sim IP$$

② Grünbaum's Argument

$$PIP \rightarrow FSP$$
$$T \rightarrow \sim FSP \rightarrow \sim PIP$$

③ Causal Paradox Argument

$$IP \wedge T \rightarrow \text{contradiction}$$
$$\therefore T \rightarrow \sim IP$$

or $IP \wedge T \wedge S \rightarrow$ contr.

$$\therefore T \rightarrow (\sim IP) \vee \sim S$$

where S = Tachyon Signal Hypothesis

ENERGY AND MOMENTUM OF A TACHYON

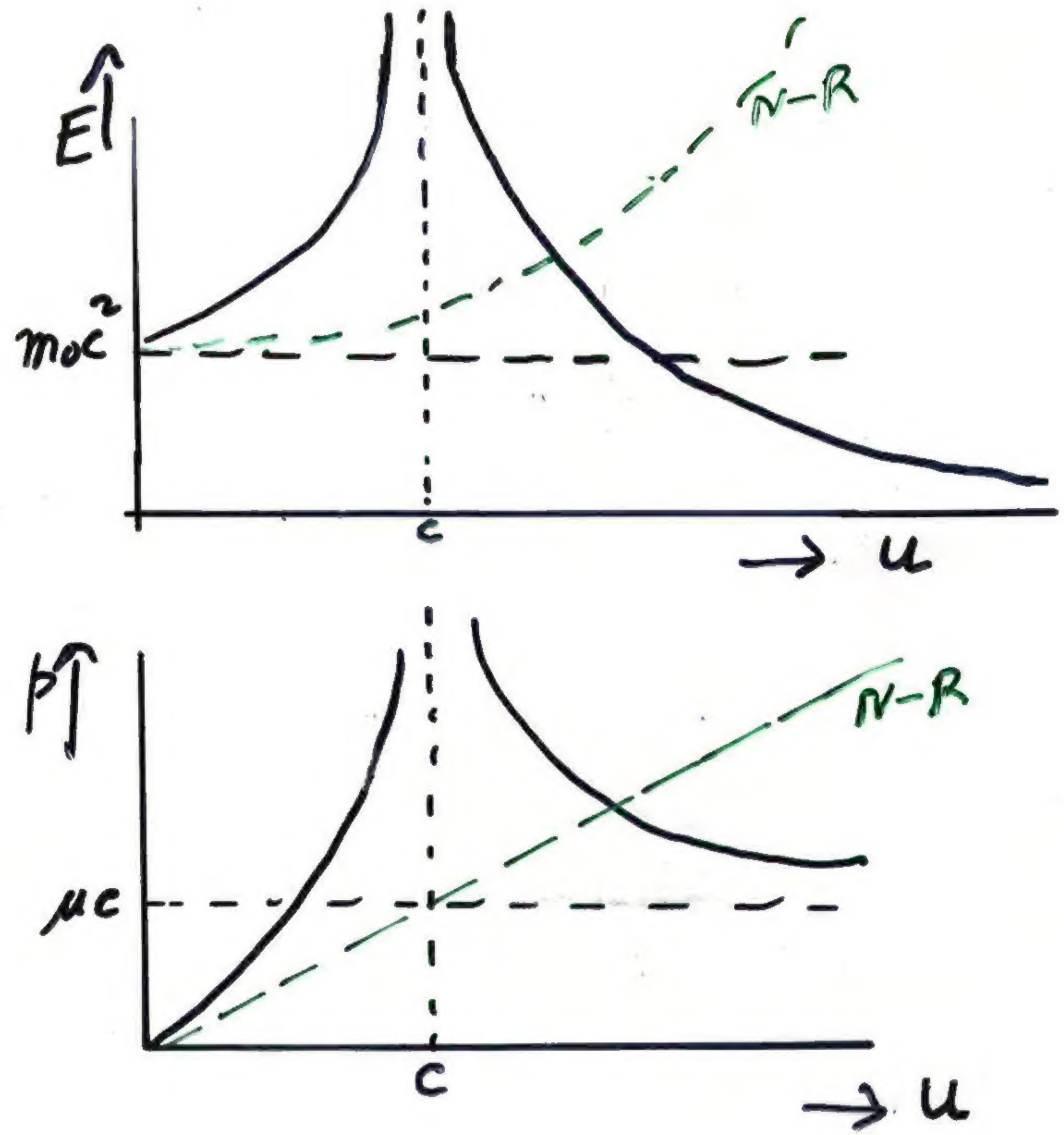
For Bradyons

$$E = \frac{m_0 c^2}{\sqrt{1 - u^2/c^2}} \quad , \quad \underset{\sim}{p} = \frac{E \underset{\sim}{u}}{c^2}$$

For Tachyons $m_0 \to i\mu$

So

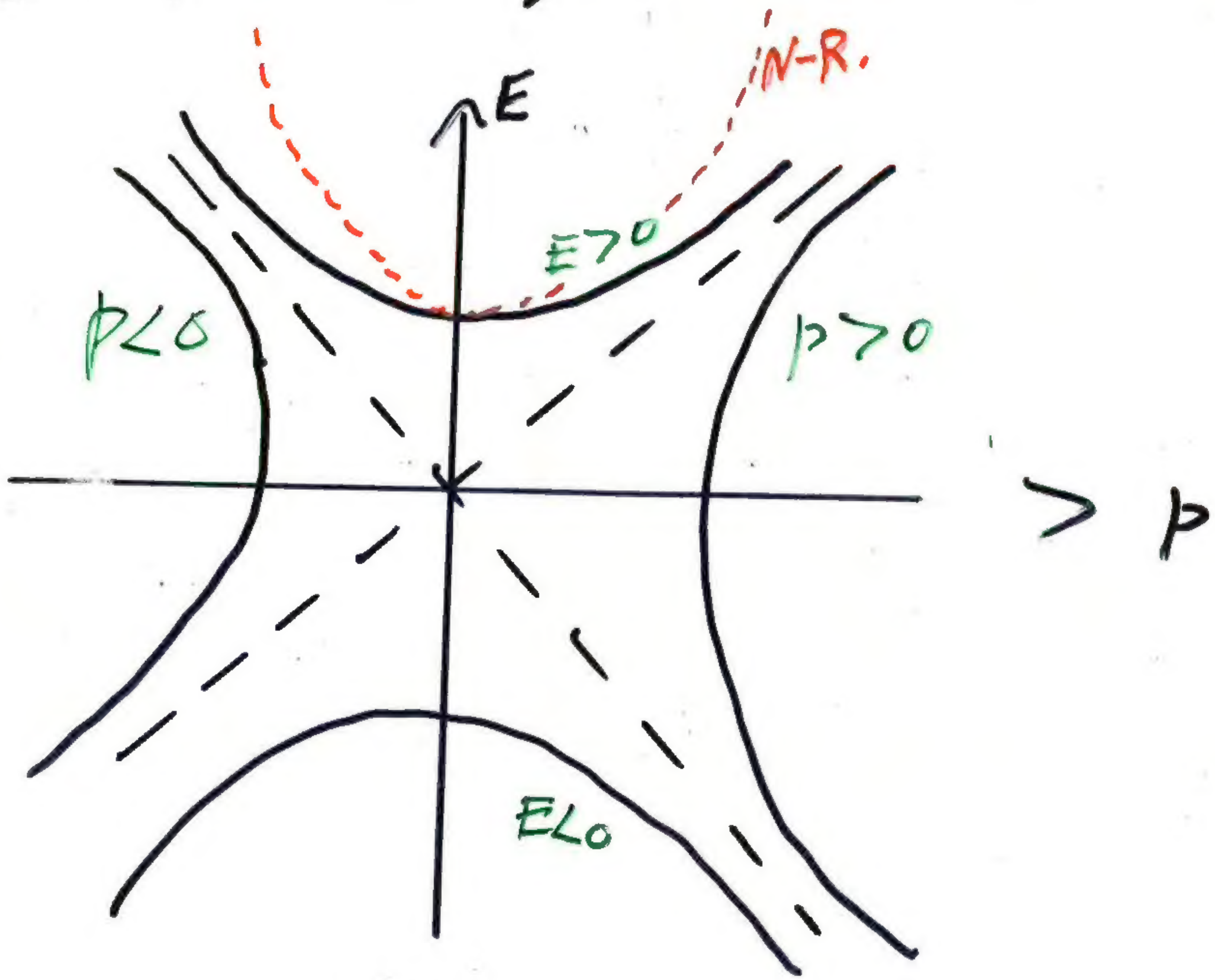
$$E = \frac{\mu c^2}{\sqrt{u^2/c^2 - 1}} \quad , \quad \underset{\sim}{p} = \frac{E \underset{\sim}{u}}{c^2}$$



E
m_0c^2
N-R
c
→ u
p
μc
N-R
c
→ u

$$E^2 - p^2c^2 = m_0^2 c^4 \qquad u < c$$

$$E^2 - p^2c^2 = -\mu^2 c^4 \qquad u > c$$



N.B. $u = \frac{dE}{dp}$

ENERGY AND TIME-ORDER CHANGE SIGN TOGETHER ON A TACHYON TRAJECTORY

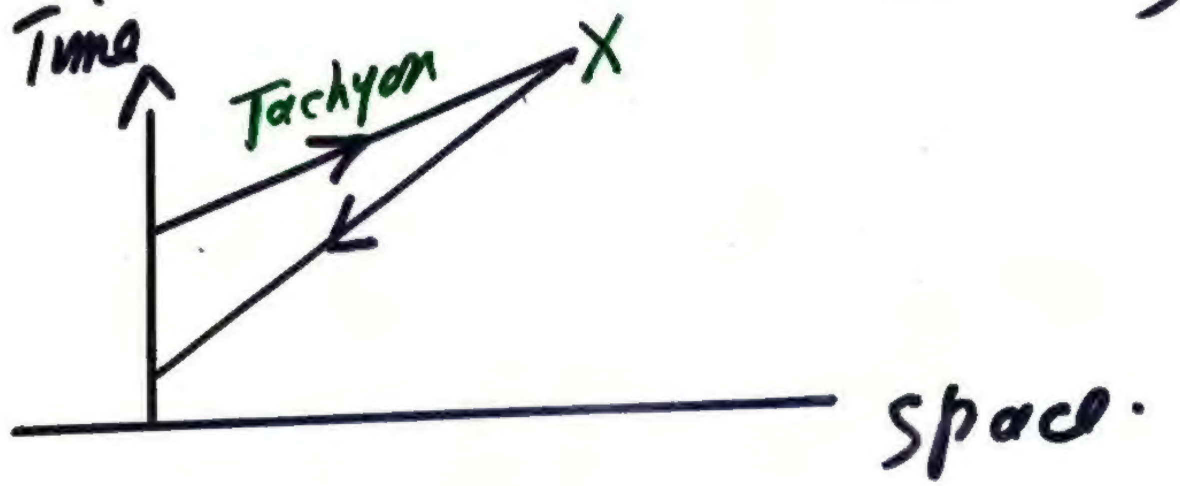
$$E' = \frac{E}{\sqrt{1-v^2/c^2}}\left(1 - \frac{v u_x}{c^2}\right)$$

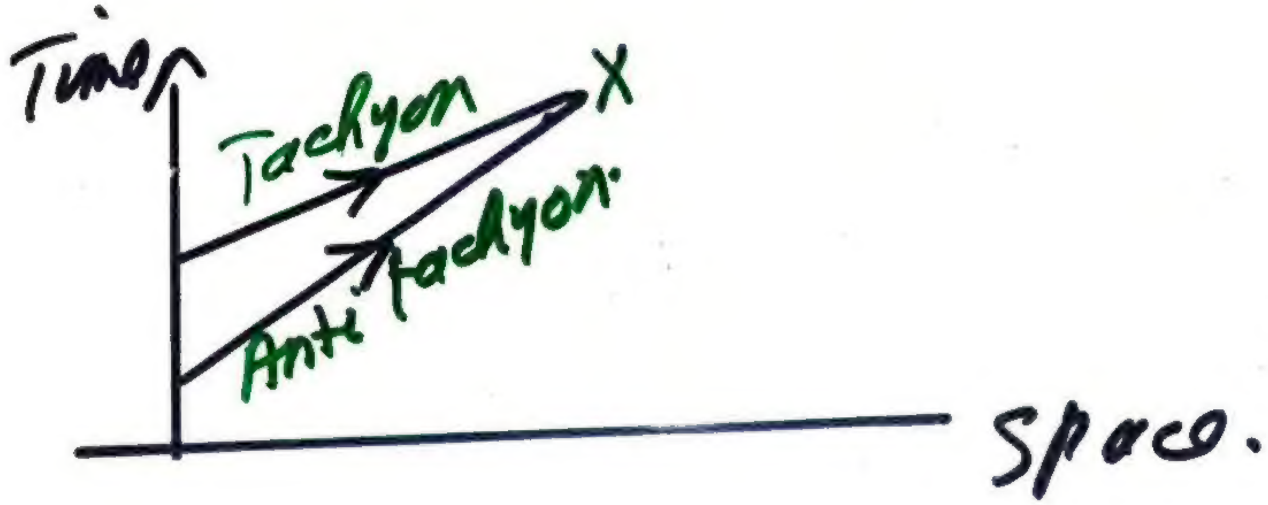
changes sign when $v > \frac{c^2}{u_x}$

$$t_2' - t_1' = \frac{t_2 - t_1}{\sqrt{1-v^2/c^2}}\left(1 - \frac{v u_x}{c^2}\right)$$

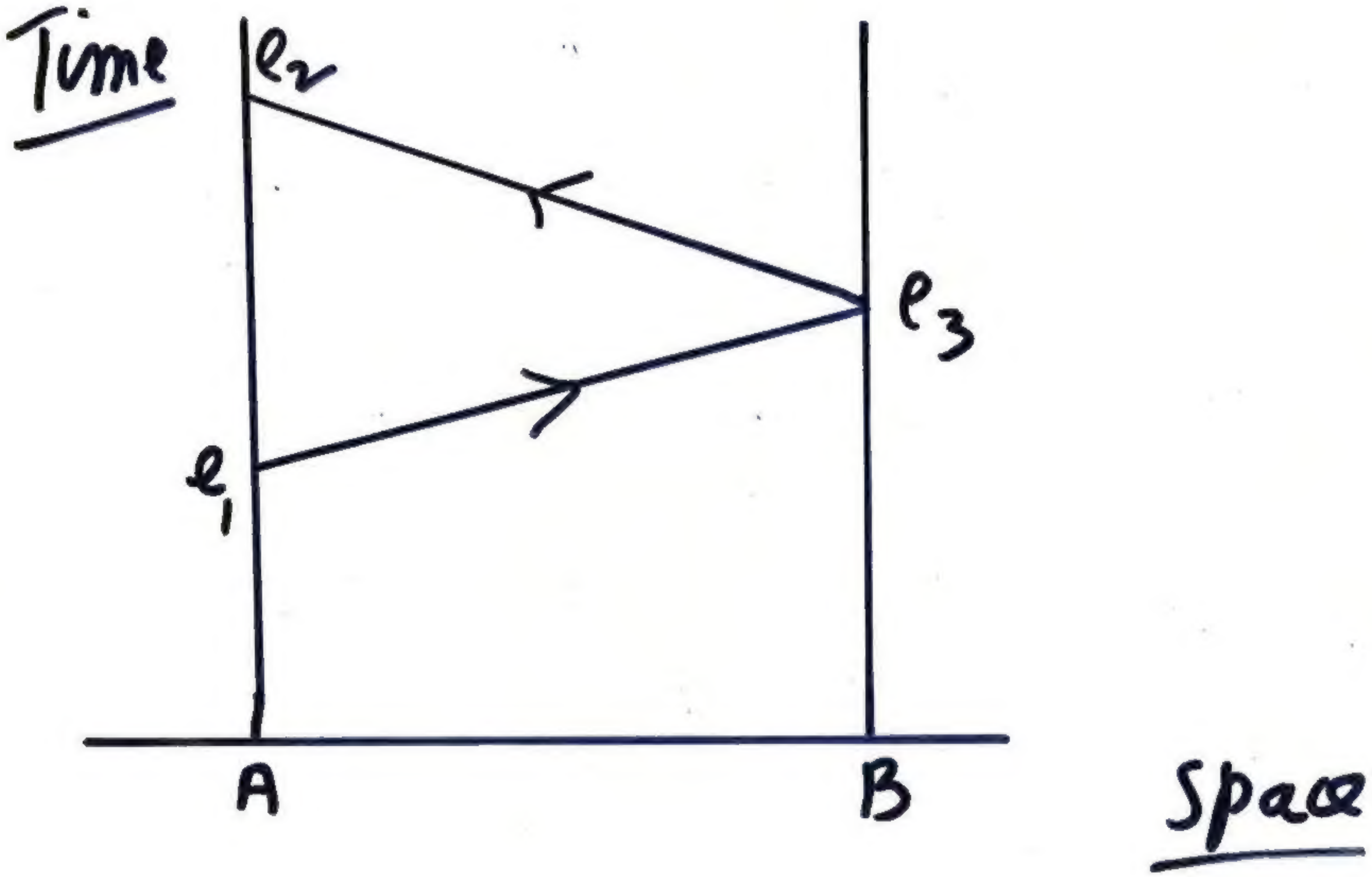
also changes sign when $v > \frac{c^2}{u_x}$

THE REINTERPETATION PRINCIPLE (RIP)

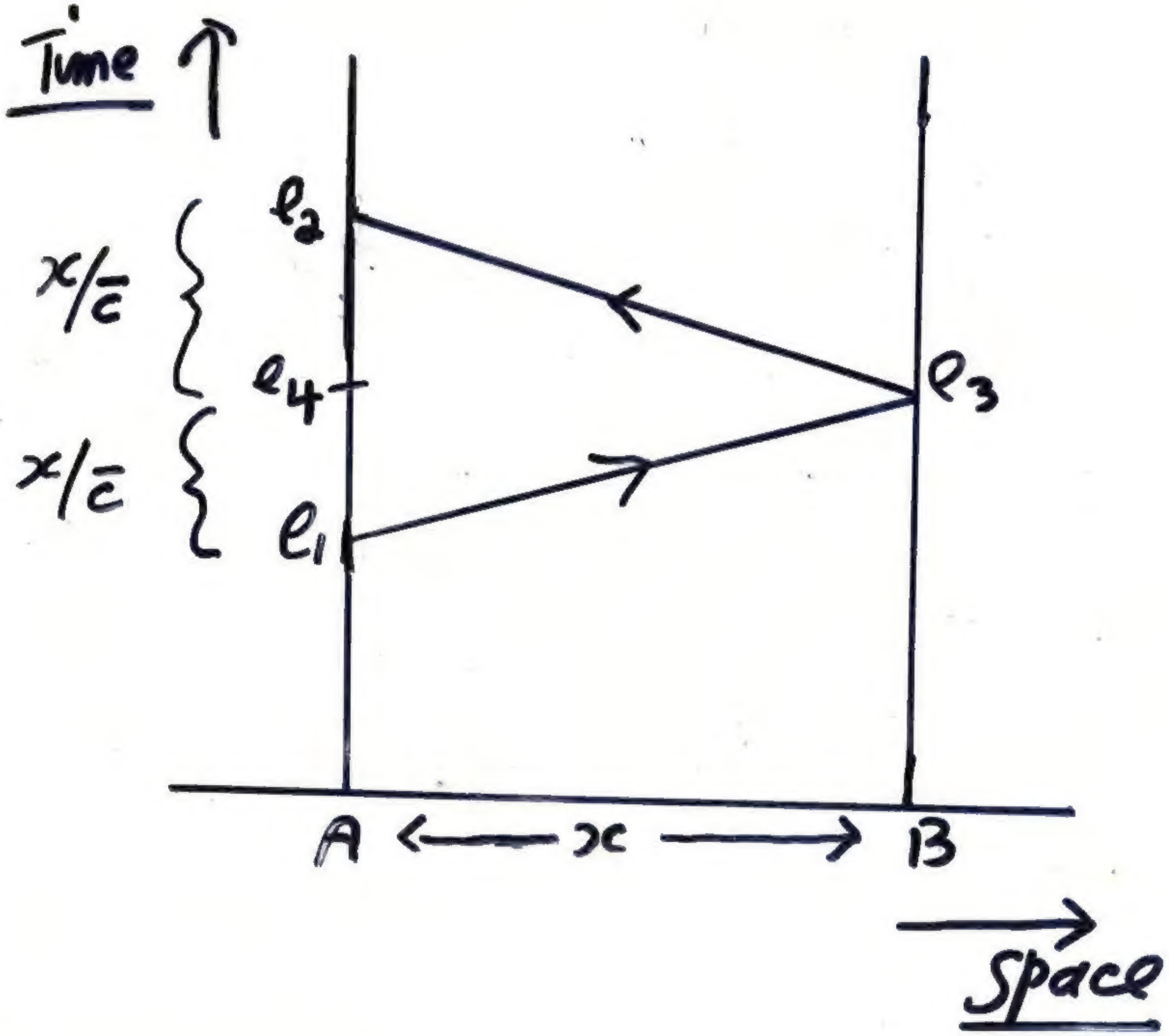




CONVENTIONALITY OF SIMULTANEITY



CONVENTIONALITY OF SIMULTANEITY. contd



$G =$ variable ranging over complete genidentical sets

$S =$ variable ranging over continuous genidentical sets

So $\forall S \exists G (S \subseteq G)$

We write $e_1 \in G \wedge e_2 \in G \wedge \ldots$ as $G(e_1, e_2 \ldots)$

<u>Betweenness</u>

$e_3 B e_1 e_2$ iff $\exists G [G(e_1, e_2, e_3) \wedge \forall S (S \subseteq G - \{e_3\} \rightarrow \sim S(e_1, e_2))]$

<u>Simultaneity</u>

$e_3 S_R e_4$ iff $\forall e_5 \forall G (\sim G(e_3, e_4, e_5))$.

THE FIRST SIGNAL PRINCIPLE

$$\exists e_1 \exists e_2 \left[e_3 \mathcal{B} e_1 e_2 \wedge \forall e_4 \left(e_4 \mathcal{B} e_1 e_2 \rightarrow e_3 S_R e_4 \right) \right]$$

cp Grünbaum's defn of Simultaneity

$$e_3 S_G e_4 \text{ iff } \forall G \left(\sim G(e_3, e_4) \right)$$

N.B $e_3 S_G e_4 \longrightarrow e_3 S_R e_4$

THE REICHENBACH ε- PARAMETER

$$t_3 = t_1 + \varepsilon(t_2 - t_1)$$

$$0 < \varepsilon < 1$$

$$\vec{c} = \frac{x}{t_3 - t_1} = \frac{\bar{c}}{2\varepsilon}$$

$$\overleftarrow{c} = \frac{x}{t_2 - t_3} = \frac{\bar{c}}{2(1-\varepsilon)}$$

where $\bar{c} = 2x / t_2 - t_1$

with $\varepsilon = \frac{1}{2}$, $\vec{c} = \overleftarrow{c} = \bar{c} = c$

TRANSFORMATION BETWEEN MOVING REFERENCE FRAMES

$$\left.\begin{aligned} x' &= Ax + Bt \\ t' &= Ct + Dx \end{aligned}\right\}$$

For $x'=0$, $x = vt$ so $B = -Av$

Define $m = -D/C$

Then
$$\left.\begin{aligned} x' &= A(x - vt) \\ t' &= C(t - mx) \end{aligned}\right\}$$

Now suppose moving rod is contracted by a factor $\underline{F}$ and a moving clock is dilated by a factor $\underline{G}$

Then $A = 1/F$

$$C = \frac{1}{G(1-mv)}$$

So

$$\left.\begin{aligned} x' &= \frac{1}{F}(x - vt) \\ t' &= \frac{1}{G(1-mv)}(t - mx) \end{aligned}\right\}$$

$t' = 0$ has locus $t = mx$ in K

so m is the slope of the line of simultaneity

ACOUSTIC SYNCHRONIZATION

$$U_x' = A/C \frac{U_x - v}{1 - m U_x}.$$

Put $U_x = \pm\,\omega$ and equate magnitudes of U_x'

$$\Longrightarrow \quad m = v/\omega^2$$

So

$$\left.\begin{aligned} x' &= 1/F\,(x - vt) \\ t' &= \frac{1}{G(1-v^2/\omega^2)}\left(t - \frac{vx}{\omega^2}\right) \end{aligned}\right\}$$

ACOUSTIC RELATIVITY

Newtonian world $F = G = 1$

so
$$x' = x - vt$$
$$t' = \frac{1}{1 - v^2/w^2}\left(t - vx/w^2\right)$$

(Zahar 1977)

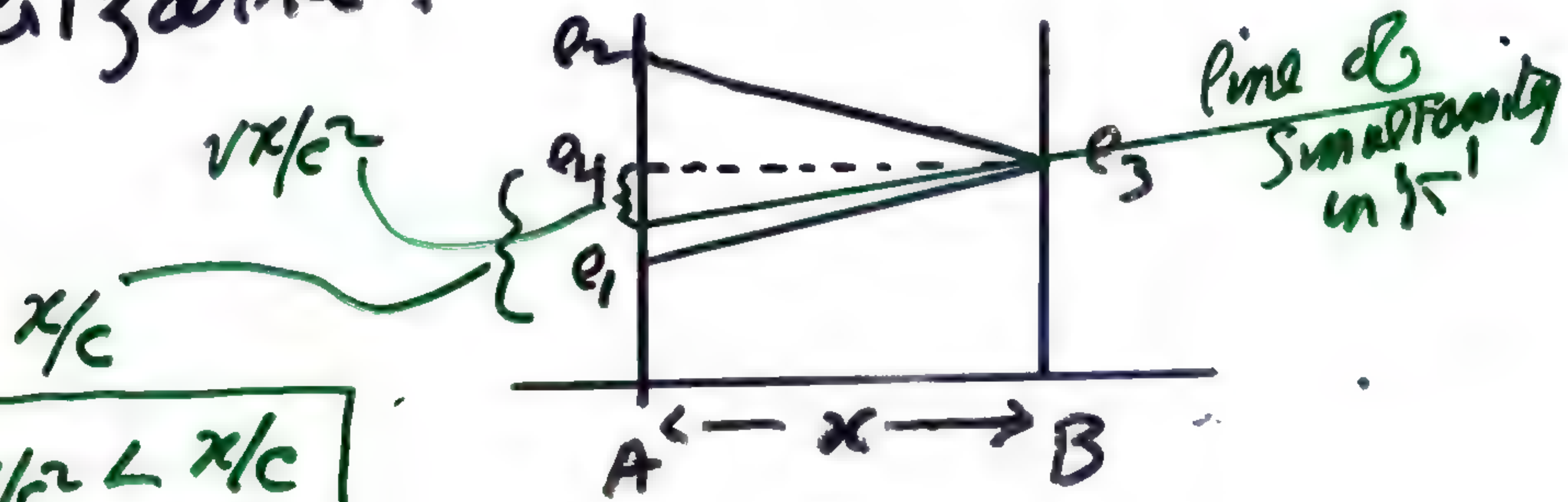
Einsteinian world $F = 1/G = \sqrt{1 - v^2/c^2}$

$$x' = \frac{1}{\sqrt{1 - v^2/c^2}}(x - vt)$$
$$t' = \frac{\sqrt{1 - v^2/c^2}}{1 - v^2/w^2}\left(t - vx/w^2\right)$$

BIZARRE SYNCHRONIZATION

A choice of synch. in K' is said to be <u>bizarre</u> if it makes metrically simultaneous in K' events which are <u>not</u> topologically simultaneous in K.

<u>THEOREM</u> The Einstein Convention for optical Relativity is never bizarre.



$$\boxed{\begin{array}{c} vx/c^2 < x/c \\ \text{if } v < c \end{array}}$$

<u>Theorem</u>

The Einstein Convention for Acoustic Relativity is bizarre for

$$v > \left(\frac{\omega}{c}\right) \cdot \omega$$

$$\left(\text{i.e. when } \frac{vx}{\omega^2} > \frac{x}{c} \right)$$

ε- RELATIVITY

$$x'' = x'$$
$$t'' = t' + \frac{x'}{\omega'}(2\varepsilon - 1)$$

So

$$x'' = \frac{1}{\sqrt{1-v^2/c^2}}(x - vt)$$

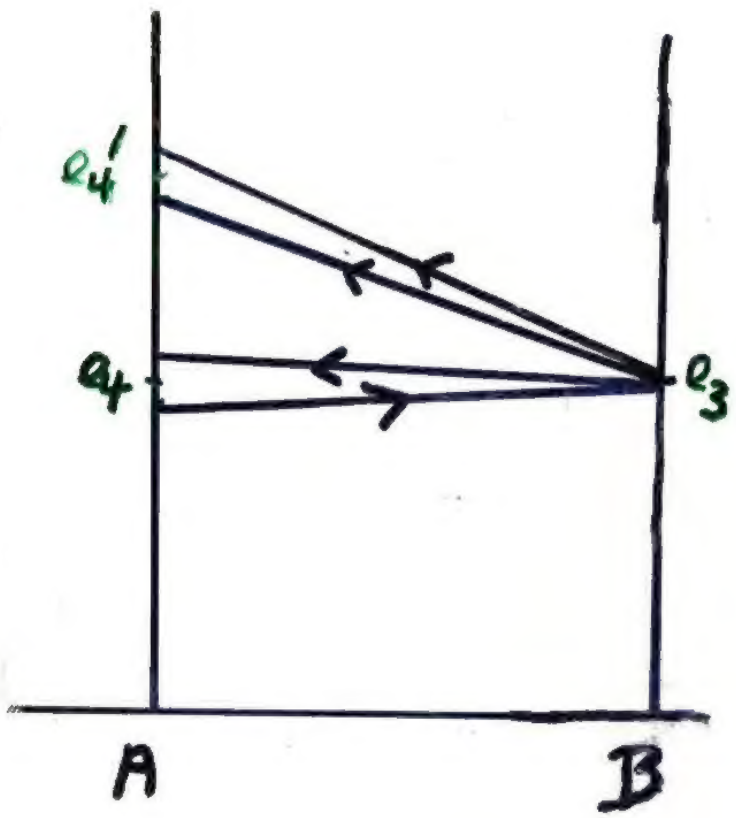
$$t'' = \frac{\sqrt{1-v^2/c^2}}{1-v^2/\omega^2}\Big[t\big(1 - v/\omega\,(2\varepsilon-1)\big) + x/\omega\,(2\varepsilon - 1 - v/\omega)\Big]$$

To eliminate relativity of Simultaneity choose $\varepsilon = \frac{1}{2} + v/2\omega$.

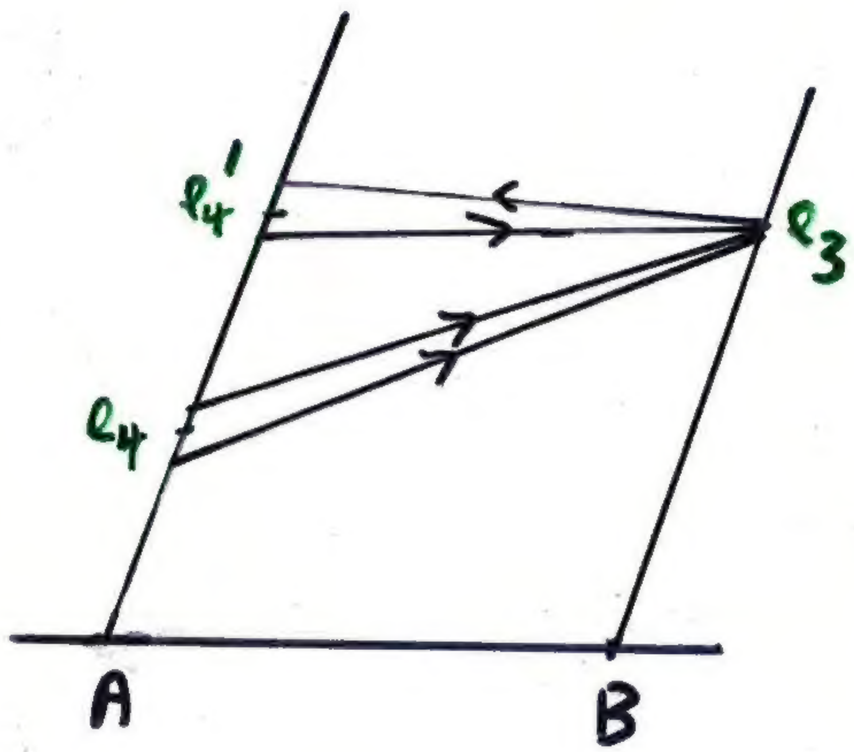
THE SJÖDIN - TANGHERLINI TRANSFORMATION

$$\left.\begin{aligned} x'' &= \frac{1}{\sqrt{1-v^2/c^2}}(x-vt) \\ t'' &= \sqrt{1-v^2/c^2}\cdot t \end{aligned}\right\}$$

TACHYON SYNCHRONIZATION

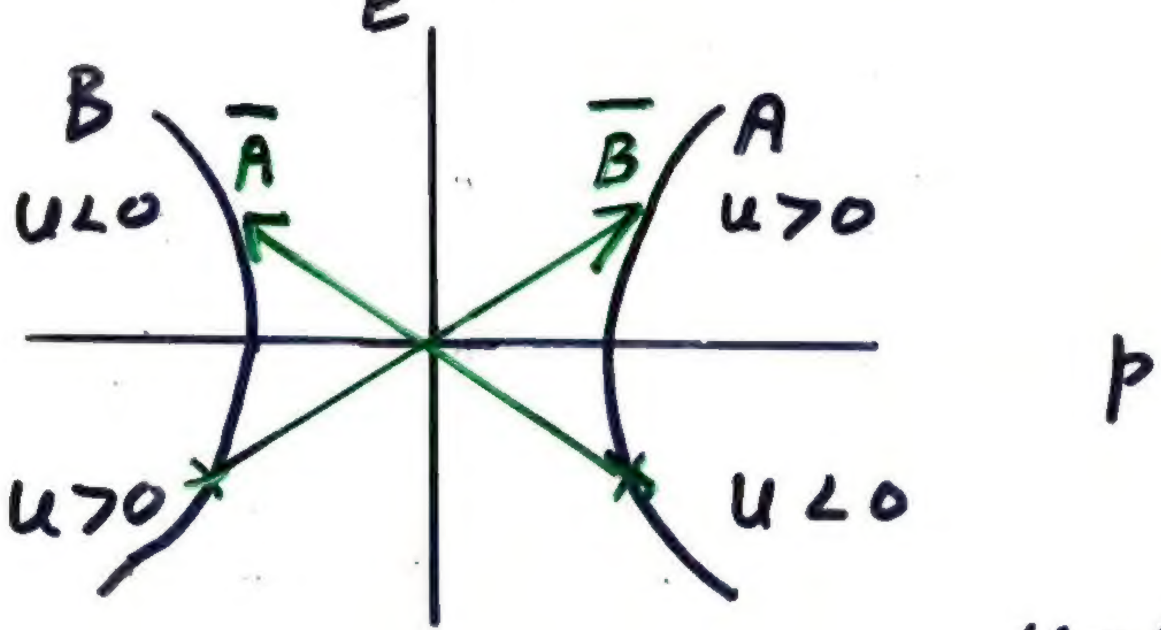


K



K'

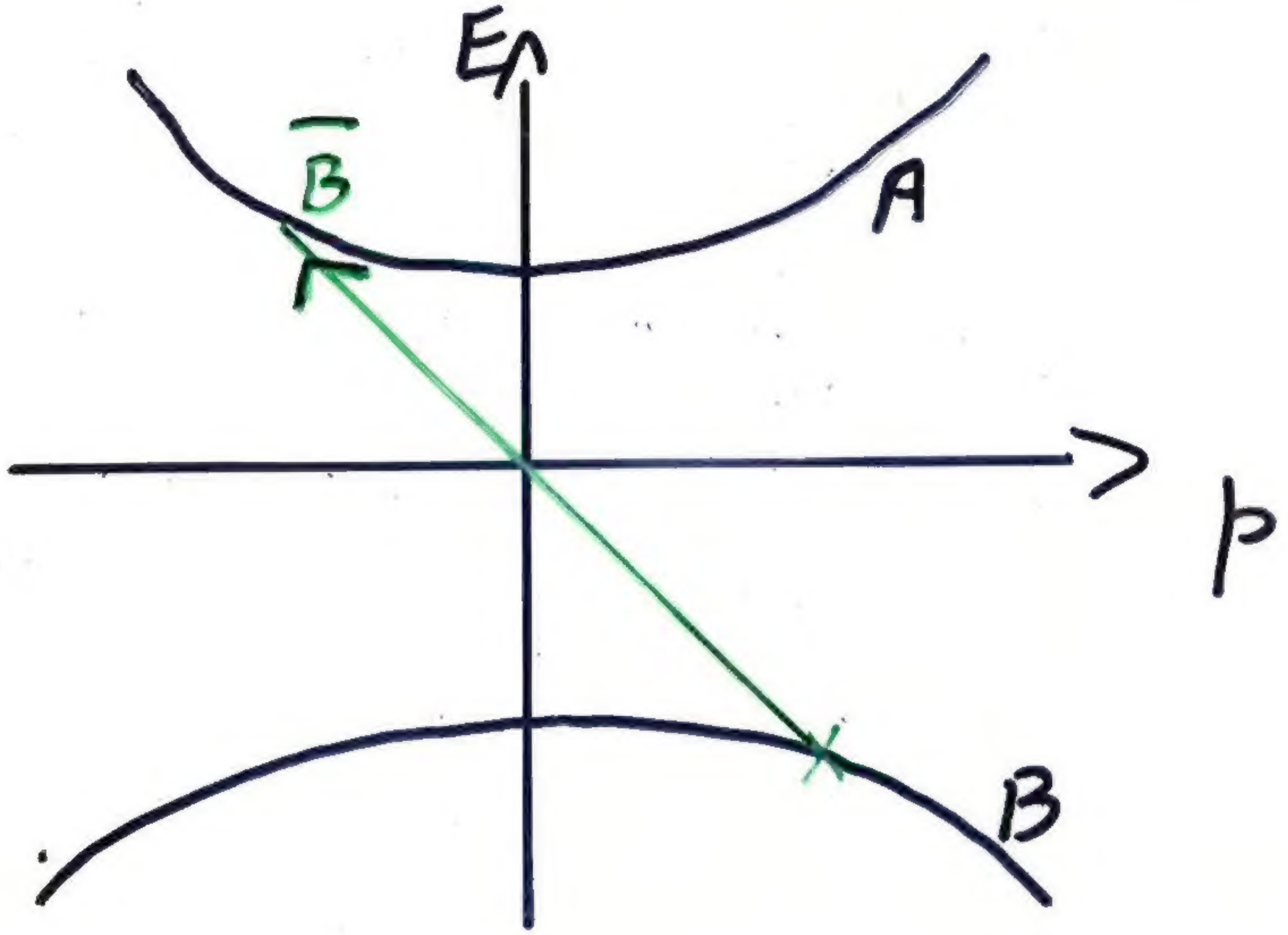
ONE-DIMENSIONAL TACHYONS



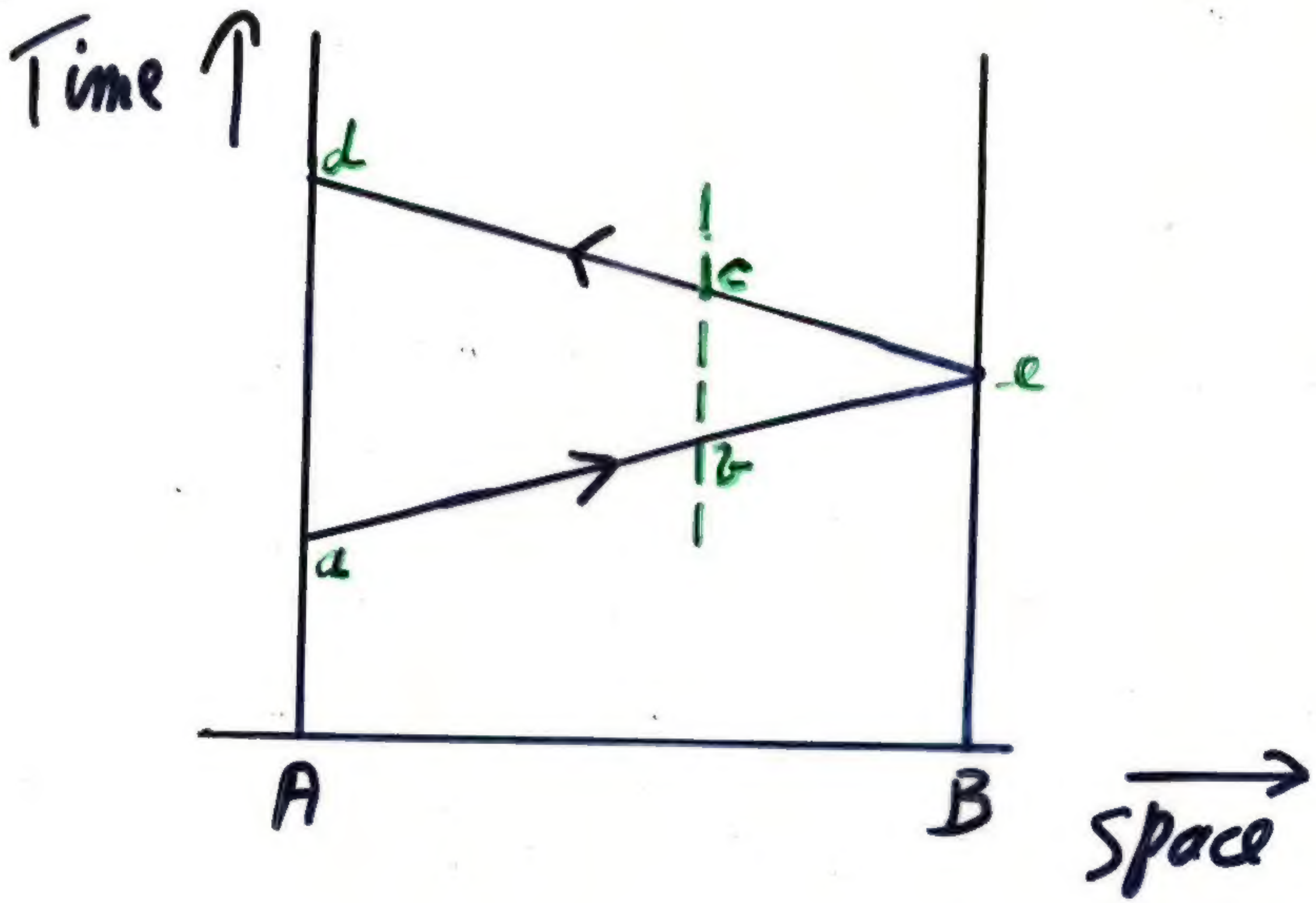
$$u = \frac{dE}{dp}$$

Particles moving to the right are $A, \bar{B}$
" " " " left " $B, \bar{A}$

BRADYON ANTIPARTICLES



Particles moving to the right are A, $\overline{B}$
" " " " left " A, $\overline{B}$



GENIDENTITY AND SPATIO
- TEMPORAL CONTINUITY